CLAIMS

1. A method of determining the blood flow rate Q_F in a blood-carrying line (40), of which blood a portion is branched off at a first location (12) through an arterial line (14) and through a venous line (15) and is returned at a second location (13), whereby

   a physicochemical variable Y of the blood, which is constant over a period of time for a measurement interval, is determined in the arterial line (14) as having the value Y_A and is determined in the venous line (15) as having the value Y_V,

   the net rate dX/dt of a variable X derived from the physicochemical variable Y into or out of the blood-carrying line (40) during the measurement interval is determined from the values Y_A and Y_V as the difference between the rate dX_A/dt removed through the arterial line (14) and the rate dX_V/dt supplied through the venous line (15), and

   the net rate dX/dt is used to determine the blood flow rate Q_F.

2. The method according to Claim 1, characterized in that the blood flow rate Q_B is determined in the arterial line (14) and in the venous line (15) for the determination of the rate removed dX_A/dt and the rate supplied dX_V/dt.

3. The method according to Claim 2, characterized in that the physicochemical variable Y is the thermal energy per unit of volume of blood, and the variable X, which is derived from it, denotes the thermal energy E of the blood in the blood-carrying line (40).

4. The method according to Claim 3, characterized in that the temperatures T_A in the arterial line (14) and T_V in the venous line (15) are determined for the determination of the net thermal energy rate dE/dT, and the net energy rate is determined on the basis of the equation

$$\frac{dE}{dt} = \frac{dE_V}{dt} - \frac{dE_A}{dt} = c_E \rho_B Q_B (T_V - T_A)$$

where c_E is the specific thermal capacity and ρ_B is the density of the blood.

5. The method according to Claim 2, characterized in that the physicochemical variable Y is the concentration c of a substance in blood, and X is the quantity C of the substance in the blood-carrying line (40).

6. The method according to Claim 5, characterized in that the concentrations c_A of the substance in the arterial line (14) and c_V in the venous line (15) are determined for the determination of the net substance quantity rate dC/dt, and the net substance quantity rate is determined according to the equation:

$$\frac{dC}{dt} = \frac{dC_V}{dt} - \frac{dC_A}{dt} = Q_B (c_V - c_A)$$

7. The method according to one of the preceding Claims, characterized in that the arterial line (14) branches off from the blood-carrying line (40) upstream from the venous line (15), and the blood flow rate Q_F is determined on the basis of the equation:

$$Q_F = \frac{\frac{dX}{dt}}{Y_V - Y_B}$$

where Y_B is the physicochemical variable in the blood-carrying line (40) upstream from the branch (12) in the arterial line (14).

8. The method according to one of Claims 2 through 6, characterized in that the arterial line (14) branches off from the blood-carrying line (40) downstream from the venous line (15), where the net rate is designated as dX_{rec}/dt, and the physicochemical variable in the venous line is designated as $Y_{V,rec}$, and the blood flow rate Q_F is determined on the basis of the equation:

$$Q_F = \frac{Q_B \frac{dX_{rec}}{dt}}{Q_B (Y_{V,rec} - Y_B) - \frac{dX_{rec}}{dt}}$$

where X_B is the physicochemical variable in the blood-carrying line (40) upstream from the branch (13) in the venous line (15).

9. The method according to one of Claims 2 through 6, characterized in that both the net rate dX/dt with the upstream branch in the arterial line (14) relative to the venous line (15) from the blood-carrying line (40) as well as the net rate dX_{rec}/dt with a downstream branch in the arterial line (14) relative to the venous line (15) from the blood-carrying line (40) are determined at the same blood flow rate Q_B, and the blood flow rate Q_F is determined according to the following equation:

$$Q_F = \frac{Z}{1-Z} Q_B \quad \text{where} \quad Z = \frac{\frac{dX_{rec}}{dt}}{\frac{dX}{dt}} \frac{Y_V - Y_A}{Y_{V,rec} - Y_A} .$$

10. A device for measuring the blood flow in the blood-carrying line (40), comprising

an arterial line (14) branching off from the blood-carrying line (40) with which blood is removed from the blood-carrying line;

a venous line (15) opening into the blood-carrying line (40) with which blood is supplied to the blood-carrying line;

arterial measurement means (20) and venous measurement means (22) for determining a physicochemical variable Y of the blood in the arterial line (14) with the value Y_A and in the venous line (15) with the value Y_B, these variables being constant over a period of time for a measurement interval;

an analyzer unit (27) connected to the arterial measurement means (20) and the venous measurement means (22), this analyzer unit being suitable for determining the net rate dX/dt of a variable X derived from the physicochemical variable Y into or from the blood-carrying line (40) during the measurement interval as the difference between the rate dX_A/dt removed through the arterial line (14) and the rate dX_V/dt supplied through the venous line (15) from the values Y_A and Y_V, and it is also suitable for using the net rate dX/dt to determine the blood flow rate Q_F.

11. The device according to Claim 10, characterized in that means (18) are provided for detecting and/or adjusting the blood flow rate Q_B in the arterial line (14) and in the venous line (15).

12. The device according to Claim 11, characterized in that the means for detecting the blood flow rate Q_B consist of a flow sensor, which is connected to the analyzer unit (27).

13. The device according to Claim 12, characterized in that the means for detecting the blood flow rate Q_B consists of a control unit (18) which is used for setting a delivery rate of a blood pump (16), which is situated in the arterial line (14) and/or the venous line (15) and is connected to the analyzer unit (27).

14. The device according to one of Claims 11 through 13, characterized in that the physicochemical variable Y denotes the thermal energy per unit of volume of blood, and the variable X derived therefrom denotes the thermal energy E of the blood in the blood-carrying line (40).

15. The method according to Claim 14, characterized in that the measurement means (20, 22) in the arterial line (T_A) and the venous line (T_V) are temperature sensors for determining the net thermal energy rate dE/dt, and the analyzer unit (27) is suitable for determining the net thermal energy rate by using the equation:

$$\frac{dE}{dt} = \frac{dE_V}{dt} - \frac{dE_A}{dt} = c_E \rho_B Q_B (T_V - T_A)$$

where c_E is the specific thermal capacity, and ρ_B is the density of blood.

16. The device according to one of Claims 11 through 13, characterized in that the physicochemical variable is the concentration c of a substance in the blood, and X is the quantity C of this substance in the blood-carrying line (40).

17. The device according to Claim 16, characterized in that to determine the net substance quantity dC/dt, the measurement means (20, 22) in the arterial line (c_A) and in the venous line (c_V) are concentration sensors, and the analyzer unit (27) is suitable for determining the net substance quantity rate on the basis of the equation:

$$\frac{dC}{dt} = \frac{dC_V}{dt} - \frac{dC_A}{dt} = Q_B(c_V - c_A)$$

18. The device according to one of Claims 10 through 17, characterized in that the arterial line (14) branches off from the blood-carrying line (40) upstream from the venous line (15), and the analyzer unit (27) is suitable for performing a determination of the blood flow rate Q_F on the basis of the equation:

$$Q_F = \frac{\frac{dX}{dt}}{Y_V - Y_B}$$

where Y_B is the physicochemical variable in the blood-carrying line (40) upstream from the branch (12) in the arterial line (14).

19. The device according to one of Claims 11 through 17, characterized in that the arterial line (14)

branches off from the blood-carrying line (40) upstream from the venous line (15), whereby the net rate is designated as dX_{rec}/dt and the physicochemical variable in the venous line is designated as $Y_{V,rec}$, and the analyzer unit (27) is suitable for performing a determination of the blood flow rate Q_F by using the equation:

$$Q_F = \frac{Q_B \frac{dX_{rec}}{dt}}{Q_B(Y_{V,rec} - Y_B) - \frac{dX_{rec}}{dt}}$$

where Y_B is the physicochemical variable in the blood-carrying line (40) upstream from the branch (13) and in the venous line (15).

20. The device according to one of Claims 11 through 17, characterized in that the analyzer unit (27) is suitable for determining both the net rate dX/dt with an upstream branch in the arterial line (14) with respect to the venous line (15) from the blood-carrying line (40) as well as the net rate dX_{rec}/dt with a downstream branch in the arterial line (12) with respect to the venous line (15) from the blood-carrying line (40) at the same blood flow rate Q_B, and then from that determining the blood flow rate Q_F according to the following equation:

$$Q_F = \frac{Z}{1-Z} Q_B \quad \text{where} \quad Z = \frac{\frac{dX_{rec}}{dt}}{\frac{dX}{dt}} \frac{Y_V - Y_A}{Y_{V,rec} - Y_A}.$$

21. The device according to one of Claims 10 through 20, characterized in that the arterial line (14) and the venous line (15) are part of an extracorporeal blood circulation system (2) of a blood treatment device.

22. The device according to Claim 21, characterized in that the blood treatment device is a hemodialysis device.

23. The device according to Claims 21 or 22, characterized in that the blood flow rate Q_F to be determined is the blood flow in a blood vessel, in particular an arteriovenous fistula or a shunt, in a patient.

24. The device according to one of Claims 10 through 23, characterized in that device has a display unit (28) suitable for displaying the blood flow rate Q_F.